

Enclosure 3  
~~Attachment B~~

State of California  
AIR RESOURCES BOARD

**PROPOSED**

CALIFORNIA EXHAUST EMISSION STANDARDS AND TEST PROCEDURES  
FOR 2001 MODEL YEAR AND LATER  
SPARK-IGNITION MARINE ENGINES

Adopted: December 10, 1998

Amended: \_\_\_\_\_

NOTE: ~~This is a new regulation proposed for adoption. All language is new and set forth in standard type.~~ This document is printed in a style to indicate changes from the existing provisions. All existing language is indicated by plain text. All additions and deletions to language therein are indicated by underline and ~~strikeout~~, respectively. The numbering convention employed in this document, in order of priority, is: I.1.a.1.i.A.

CALIFORNIA EXHAUST EMISSION STANDARDS AND TEST PROCEDURES  
FOR 2001 MODEL YEAR AND LATER SPARK-IGNITION MARINE ENGINES

**Part I.        Emission Regulations for 2001 and Later New Spark-Ignition Marine Engines, General Provisions.**

**1.        General Applicability.**

- (a)    (1)    This rule applies to model year 2001 and subsequent model year spark-ignition (SI) marine engines used to propel marine vessels as defined in the General Provisions of the United States Code, 1 U.S.C.3 (1992), unless otherwise indicated.
- (2)    Sterndrive and inboard engines are exempt from this rule.
- (3)    Every new spark-ignition marine engine that is manufactured for sale, sold, or offered for sale in California, or that is introduced, and delivered or imported into California for introduction into commerce, and which is subject to any of the standards prescribed in this article must be covered by an Executive Order, issued pursuant to this article.
- (b)    Each part of this article is severable, and in the event that any part of this chapter is held to be invalid, the remainder of this article remains in full force and effect.
- (c)    (1)    For purposes of this article, military tactical vehicles or equipment means vehicles or equipment owned by the U.S. Department of Defense and/or the U.S. military services and used in combat, combat support, combat service support, tactical or relief operations, or training for such operations.
- (2)    This article shall not apply to engines used in off-road military tactical vehicles or equipment which have been exempted from regulations under the federal national security exemption, 40 CFR, subpart J, section 90.908, which is incorporated by reference herein. It shall also not apply to those vehicles and equipment covered by the definition of military tactical vehicle that are commercially available and for which a federal certificate of conformity has been issued under 40 CFR Part 91. subpart B, which is incorporated by reference herein.
- (3)    The U.S. Department of Defense shall submit to the ARB a list of all vehicles and equipment that are exempted under the above provisions and which are located in the State of California. If any additional vehicle and

equipment types are added to the list, the U.S. Department of Defense shall update the list and submit it to the ARB by January 1 of the following year.

**9. Exhaust Emission Standards for 2001 and Later Spark-Ignition Marine Engines.**

- (a) Exhaust emissions from new spark-ignition marine engines manufactured for sale, sold, or offered for sale in California, or that are introduced, delivered or imported into California for introduction into commerce, must not exceed the following standards:

Corporate Average Emission Standards by Implementation Date  
HC+NO<sub>x</sub> (in g/kW-hr)

Model Year	Max. Family Emission Limit (FEL)	$P_{tx} < 4.3$ kW	$P_{tx} \geq 4.3$ kW
2001	<del>134</del> <u>Not Applicable</u>	81.00	$(0.25 \times (151 + 557/P_{tx}^{0.9})) + 6.00$
2004	80	64.80	$(0.20 \times (151 + 557/P_{tx}^{0.9})) + 4.80$
2008	<del>40</del> <u>44</u>	30.00	$(0.09 \times (151 + 557/P_{tx}^{0.9})) + 2.10$

where:

$P_{tx}$  is the average power in kW (sales-weighted) of the total number of spark-ignition marine engines produced for sale in California in model year x. Engine power must be calculated using the Society of Automotive Engineers (SAE) standard J1228, November 1991, incorporated herein by reference. Engine manufacturers must not determine  $P_{tx}$  by combining the power outputs of outboard engines with the power outputs of personal watercraft engines.

- (b) An engine manufacturer may comply with the standards directly on an individual engine family basis. Consequently in Table 1, FELs are not applicable for any model year and  $P_{tx}$  means the average power in kW (sales-weighted) of the subject engine family produced for sale in California in model year x.

Compliance with the standards on a corporate average basis will be determined as follows:

$$\frac{\sum_{j=1}^n (PROD_{jx})(FEL_{jx})(P_{jx})}{\sum_{j=1}^n (PROD_{jx})(P_{jx})} = STD_{ca}$$

where:

n = total number of engine families (by category)

PROD<sub>jx</sub> = number of units of each engine family j produced for sale in California in model year x.

FEL<sub>jx</sub> = the Family Emission Limit for engine family j in model year x, which must be determined by the engine manufacturer subject to the following conditions: (1) no individual engine family FEL shall exceed the maximum allowed value as specified in the table displayed in paragraph 9(a); (2) no engine family designation or FEL shall be amended in a model year unless the engine family is recertified; and (3) prior to sale or offering for sale in California, each engine family shall be certified in accordance with section 2447 of Title 13, California Code of Regulations, and shall be required to meet the engine manufacturer's FEL as a condition of the Executive Order. Prior to certification, the engine manufacturer shall also submit estimated production volumes for each engine family to be offered for sale in California.

P<sub>jx</sub> = The average power in kW (sales-weighted) of engine family j produced for sale in California in model year x. Engine power must be calculated using SAE standard J1228, November 1991, incorporated herein by reference.

STD<sub>ca</sub> = An engine manufacturer's calculated corporate average HC+NO<sub>x</sub> exhaust emissions from those California spark-ignition marine engines subject to the California corporate average HC+NO<sub>x</sub> exhaust emission standard determined from Table 1, as established by an Executive Order certifying the California production for the model year. This Executive Order must be obtained prior to the issuance of certification Executive Orders for individual engine families for the model year, ~~and shall include; but not be limited to the following requirements:~~

- (1) For purposes of compliance under this paragraph, engine manufacturers must not corporate average outboard engine families in combination with personal watercraft engine families.
- (2) During engine manufacturer's production year, for each engine family, the manufacturer shall provide ~~the following information~~ to the Executive Officer within ~~thirty (30)~~ 45 days after the last day in each calendar quarter:
  - ~~(A) Engine identification numbers; and,~~
  - ~~(B)~~ The total number of spark-ignition marine engines produced for sale in California and their applicable FEL.
- (3) The Executive Order certifying the California production for a model year must be obtained prior to the issuance of certification Executive Orders for individual engine families for the model year.

- (4) The engine manufacturer's average pollutant exhaust emissions must meet the corporate average standard at the end of the manufacturer's production for the model year. ~~At~~ No later than 90 days after the end of the model year, the manufacturer must calculate a corrected corporate average using actual rather than projected sales.
- (5) Production and sale of spark-ignition marine engines which result in non-compliance with the California standard for the model year shall cause an engine manufacturer to be subject to civil penalties, per engine, pursuant to section 43017 of the Health and Safety Code, and subject to all other remedies available under Part 5, Division 26 of the Health and Safety Code. All excess emissions resulting from non-compliance with the California standard must be made up in the following model year.
- (6) ~~For a period of up to one quarter following the end of the model year, f~~ For each model the engine manufacturer shall submit California sales and registration data as it becomes available ninety days after the end of the model year.
- (c) In 2001 and subsequent model years, fire and police departments, and other entities that specialize in emergency response may purchase emergency equipment powered by a non-California-certified spark-ignition marine engine only when such equipment with a California-certified spark-ignition marine engine is not available. For purposes of this section, a request to purchase emergency equipment powered by a non-California-certified engine must be submitted for approval to the Executive Officer.

## **17. Engine Families and Engine Family Groups.**

- (a) Certification applications submitted by engine manufacturers must divide engines covered therein into groupings that are expected to have similar emission characteristics throughout their useful life. Each group of engines with similar emission characteristics must be defined as a separate engine family.
- (b) In order to be included within the same engine family, engines must be identical in all of the following specifications:
  - (1) The combustion cycle.
  - (2) The cooling mechanism.
  - (3) The cylinder block configuration (i.e., inline, vee, opposed, bore spacings, etc.).
  - (4) The number of cylinders.
  - (5) ~~The engine displacement class, see section 9.~~ Engines of different displacements that are within fifteen percent of the largest displacement may be included within the same engine family provided the engine displacement class requirement is satisfied.

- (6 5) The method of air aspiration.
  - (7 6) The number, location, volume, and composition of any catalytic converters.
  - (8 7) The thermal reactor characteristics.
  - (9 8) The number of carburetors, as applicable.
  - (10 9) The prechamber characteristics.
  - (11 10) The exhaust port(s) and cylinder design of two-stroke engines.
- (c) At the engine manufacturer's option, reciprocating engines identical in all the specifications listed in paragraph (b) of this section may be further divided into different engine families if the Executive Officer determines that they may be expected to have different emission characteristics. This determination will be based upon consideration of factors such as:
- (1) The bore and stroke.
  - (2) The combustion chamber configuration.
  - (3) The intake and exhaust timing method of actuation (i.e., poppet valve, reed valve, rotary valve, etc.).
  - (4) The intake and exhaust valve or port sizes, as applicable.
  - (5) The fuel system.
  - (6) The exhaust system.

## **18. Test Engines.**

- (a) Test engines will be selected by the ~~Executive Officer~~ engine manufacturer to represent each engine-displacement-system combination. The ~~Executive Officer~~ engine manufacturer will select the engine configuration (i.e., air inlet system, exhaust system, engine calibration, etc.) of each engine-displacement-system combination in the engine family that is expected to have the greatest probability of exceeding the emission standards. The Executive Officer will make the final determination whether the test engines selected by the engine manufacturer may be used for certification testing. At the manufacturer's option, the criterion for selecting the worst case engine may be that engine configuration which has the highest weighted brake-specific fuel consumption over the appropriate engine test cycle: described in section 20(b)(5).

## **19. Executive Officer's Engines.**

The Executive Officer may require ~~the testing of~~ additional tests on the engines ~~identical in all material respects to engines~~ selected in accordance with section 18 and tested in accordance with section 20.

## **20. Test Procedures, General Requirements.**

- (a) For each engine family, engine manufacturers must determine a deterioration factor for each regulated pollutant pursuant to Part II.

- (b) Certification testing of exhaust emissions.
- (1) Manufacturers of spark-ignition marine engines must use the test procedures outlined in Part IV.
  - (2) The exhaust emission test consists of prescribed sequences of engine operating conditions to be conducted on an engine dynamometer. The exhaust gases generated during engine operation are sampled either raw or dilute (as required), and specific components are analyzed through the exhaust gas analytical system. The test is designed to measure (as applicable) the concentration of hydrocarbons (HC), carbon monoxide (CO), carbon dioxide (CO<sub>2</sub>), oxides of nitrogen (NO<sub>x</sub>), exhaust volume, temperature, fuel flow, and the gross power output. The measured values are weighted and used to calculate the brake-specific emissions of each pollutant (in g/kW-hr).
  - (4) For engines with adjustable parameters, ~~manufacturers must test the engines at both extremes of the adjustment(s), as applicable~~ the Executive Officer may adjust or require to be adjusted those adjustable parameters to any specification within the adjustable range during testing to determine compliance with the requirements of this Part.
  - (5) The exhaust emission test uses prescribed sequences of engine operation as indicated in Table 20-1.

TABLE 20-1. Spark-Ignition; Marine Engine Test Cycle

Mode Number	1	2	3	4	5
Speed (%)	100	80	60	40	Idle
<del>Power</del> <u>Torque (%)</u>	100	71.6	46.5	25.3	0
Weighting Factor	0.06	0.14	0.15	0.25	0.40

- (6) Engine power (in kilowatts) must be calculated using the Society of Automotive Engineers (SAE) standard J1228, November 1991, incorporated herein by reference.
- (c) The Executive Officer will prescribe emission test procedures for any spark-ignited ~~on~~ marine engine that the Executive Officer determines is not susceptible to satisfactory testing by the methods set forth in the test procedures.
- (~~e~~ d) The Executive Officer may revise these test procedures on a case-by-case basis when a request to do so is supported by data and results, or other information, showing the necessity for the revision.

## 29. Alternative Procedure For Notification of Additions and Changes.

- (a) (1) If the engine manufacturer determines that a change in an engine family model will not ~~affect~~ result in failure of the subject engines ~~and all such engines will~~ to continue to meet applicable emission standards, an engine manufacturer may elect to notify the Executive Officer at the time such a change is made rather than in advance as required by section 28.



## Part IV. Gaseous Exhaust Test Procedures

### 19. Raw Emission Sampling Calculations.

- Derive the final test results through the steps described in this section.
- Air and fuel flow method. If both air and fuel flow mass rates are measured, the following equations are used to determine the weighted emission values for the test engine:

$$W_{NO_x} = (G_{AIRD} + G_{FUEL}) \times \frac{M_{NO_2}}{M_{EXH}} \times WNO_x \times K_H \times \frac{1}{10^6}$$

$$W_{HC} = (G_{AIRD} + G_{FUEL}) \times \frac{M_{HC_{exh}}}{M_{exh}} \times WHX \times \frac{1}{10^6}$$

$$W_{CO} = (G_{AIRD} + G_{FUEL}) \times \frac{M_{CO}}{M_{exh}} \times WCO \times \frac{1}{10^6}$$

Where:

$W_{HC}$  = Mass rate of HC in exhaust [g/hr],

$G_{AIRD}$  = Intake air mass flow rate on dry basis [g/hr],

$G_{FUEL}$  = Fuel mass flow rate [g/hr],

$M_{HC_{exh}}$  = Molecular weight of hydrocarbons in the exhaust; see the following equation:

$$M_{HC_{exh}} = 12.01 + 1.008 \times \alpha$$

Where:

$\alpha$  = Hydrocarbon/carbon atomic ratio of the fuel.

$M_{exh}$  = Molecular weight of the total exhaust; see the following equation:

$$M_{exh} = \frac{M_{HC_{exh}} \times WHC}{10^6} + \frac{28.01 \times WCO}{10^2} + \frac{44.1 \times WCO_2}{10^2} +$$

$$\frac{46.01 + WNO_x}{10^6} + \frac{2.016 \times WH_2}{10^2} + 18.01 \times (1 - K) +$$

$$28.01 \times \frac{[100 - \frac{WHC}{10^4} - WCO - WCO_2 \frac{WNO_x}{10^4} - WH_2 - 100 \times (1 - K)]}{10^2}$$

Where:

WHC = HC volume concentration in exhaust, ppmC wet

WCO = CO percent concentration in the exhaust, wet

DCO = CO percent concentration in the exhaust, dry

WCO<sub>2</sub> = CO<sub>2</sub> percent concentration in the exhaust, wet

DCO<sub>2</sub> = CO<sub>2</sub> percent concentration in the exhaust, dry

WNO<sub>x</sub> = NO volume concentration in exhaust, ppm wet

WH<sub>2</sub> = H<sub>2</sub> percent concentration in exhaust, wet

K = correction factor to be used when converting dry measurements to a wet basis. Therefore, wet concentration = dry concentration x K, where K is:

$$\frac{1}{1 + 0.005 \times (DCO + DCO_2) \times \alpha - 0.01 \times DH_2}$$

DH<sub>2</sub> = H<sub>2</sub> percent concentration in exhaust, dry, calculated from the following equation:

$$DH_2 = \frac{0.5 \times \alpha \times DCO \times (DCO + DCO_2)}{DCO + (3 \times DCO_2)}$$

W<sub>CO</sub> = Mass rate of CO in exhaust, [g/hr]

M<sub>CO</sub> = Molecular weight of CO = 28.01

W<sub>NO<sub>x</sub></sub> = Mass rate of NO<sub>x</sub> in exhaust, [g/hr]

M<sub>NO<sub>2</sub></sub> = Molecular weight of NO<sub>2</sub> = 46.01

K<sub>H</sub> = Factor for correcting the effects of humidity on NO<sub>2</sub> formation for four-stroke gasoline engines; see the equation below:

$$K_H = \frac{1}{1 - 0.0329 \times (h \underline{H} - 10.71)}$$

Where:

H = specific humidity of the intake air in grams of moisture per kilogram of dry air.

For two-stroke gasoline engines, KH should be set to 1.